Marine Wind Generator Test

Practical Sailor's search for the best marine wind generator for cruising sailors unearthed two new units that will give the old guard a run for their money. The German-made Superwind 350 and a lightweight prototype of the Air Breeze from Southwest Windpower, churned out maximum amps during four days of micro-wind turbine test.

The micro-wind turbines assembled for this comparison include the KISS High Output Wind Generator, the Rutland 913, the Superwind 350, the Ampair 100, and a prototype of the Air Breeze. The four-day test period brought a good mix of light- and strong-wind days, so testers were able to review wind generator output in a variety of conditions. Wind speeds for the 4-day period averaged 12.6 knots, with two blustery days, so we're not surprised the high-output, three-bladed wind generators topped the five-bladed ones overall.

****

Last month, Part One of *Practical Sailor*'s wind generator test "Choosing a Wind Generator," examined the various types of marine wind generators on the market today, and discussed what to consider before buying one. That article also previewed some of the key differences between the five wind generators we tested in March on the shores of Chesapeake Bay. This article examines these generators in more detail and presents the results of our field test, which tracked wind speed and output of the five wind generators over the course of four consecutive 24-hour periods.

For four days in March, the Norfolk Naval Station MWR Marina in Norfolk, Va., hosted the field-test element of our wind generator comparison. The weather delivered a good mix of light-and strong-wind days.

The turbines assembled for this comparison include the KISS High Output Wind Generator, the Rutland 913, the Superwind 350, the Ampair 100, and a prototype of the Air Breeze. (A sixth unit, the three-bladed Ampair 300, looked promising, but failed on the first day of testing. It has been repaired, and *PS* will be reviewing it in a future issue.)

The tested units fall into one of two distinct categories: three-bladed wind generators with large-diameter rotors and high maximum outputs (Superwind, KISS, and Air Breeze) and six-bladed wind generators with small-diameter rotors and lower maximum outputs (Ampair 100 and Rutland). As pointed out in last month's article, there are key differences between these types of turbines. The six-bladed units generally begin generating power in less wind and run quieter. The three-bladed units deliver significantly more amps as wind speed increases.

Wind generator makers Hamilton Ferris and Four Winds Enterprises were asked to provide products for the comparison, but neither could meet the deadline for the test. We have looked at units from these manufacturers before. The Hamilton Ferris hybrid water/wind was reviewed in our Feb. 15, 2003 issue. The earlier version of the Four Winds II was among several units compared during long-term testing in 1994 and 1995.

The long-term test (Nov. 15, 1995) evaluated several different wind generators, one at a time, over several weeks and monitored output. Ultimately, *Practical Sailor* concluded that although wind generators are effective at producing high output in ideal conditions, their output in the winds you can expect in a comfortable harbor is less than stellar when averaged over the long haul. Only one generator in that test, the Wind Baron Neo Plus (no longer available, as far as we know) delivered more than 100 amp hours over 24 hours, and none had an average daily output greater than 10 amp hours, which is less than can be expected from one 80-watt solar panel on a moderately sunny day. Until this year, one obvious question remained unanswered, however: How would various micro turbines fare if exposed to the same variable winds in the same location for a fixed period of time?

Air Breeze (prototype)

Southwest Windpower, makers of the popular AirX Marine line of wind generators, supplied us with a prototype of the Air Breeze, which will soon be sold through West Marine. The unit we tested was essentially the new Air Breeze software and blades housed in an AirX body. Note that *Practical Sailor* is withholding any final judgment on the Air Breeze, until we are able to test the final product.

The specs for our tested model were not readily available, but testers were told that they closely mirror that of the production Air Breeze, described here. The Air Breeze will be available in 12-, 24-, or 48-volt DC models and has a rated power of 200 watts at 19 knots. It uses a three-phase, brushless permanent magnet alternator, which produces AC power that is internally rectified to DC.

Turbine control is via a microprocessor-based smart internal regulator utilizing peak power tracking. However, the Air Breeze also has an internal voltage regulator with a factory set point of 14.1 volts (12-volt turbine) or 28.2 volts (24-volt system). The set point is also field adjustable to suit different charging regimes (an AGM battery, for example). This setup allows the unit to self-regulate in high winds and to automatically stop when the batteries are charged. Normal charging resumes when the battery voltage drops slightly below the fully charged level.

The body of the prototype unit (as well as the Air Breeze) was powder-coated cast aluminum. Construction of the prototype unit was excellent. Like the AirX before it, the Air Breeze has a distinct, downward pointing tail fin with a small cutout. The manufacturer says this allows for better tracking of the wind and better stability in rough seas. Oddly, testers noted this unit had more of a tendency to rotate briefly away from the wind, even in a steady breeze, but this seeking didn’t keep it from producing the second highest total output in our test.

The Air Breeze was by far the easiest unit to mount in our test. The base simply slides on and clamps to a 1½-inch diameter schedule 40 pipe, providing 360 degrees of continuous operation. The blades were constructed of glass-filled polypropylene. The maker says an improved rotor and blades will be on the production model.

Start-up speed is reported as 6 knots, while maximum or "survival speed" is listed as 96 knots, with over-speed protection provided automatically by electronic torque control, and manually by an optional stop switch. The Air Breeze also uses stall control of the blades. According to the makers, this function is much quieter than it was in previous models (such as the AirX and 403), since the stall mode is activated by the controller before the flutter RPM is reached. The result is a dramatic reduction in RPM in wind speeds above 30 knots, reduced wear on blades and bearings in high winds, and—most importantly—protection of the turbine from damage due to high winds. Stall mode is activated at about 19 knots, and will stay in effect until wind speed drops below 19 knots. If the Air Breeze senses wind speeds above 43 knots, it will shut down completely for five minutes.

The Air Breeze finished less than 6 amp hours behind the best recorded output for each 24-hour period.

Bottom Line: Pluses for the Air Breeze prototype include high output (second overall), light weight (lightest overall), quiet operation, easy installation, excellent construction, and a low price. The unit will soon be available at West Marine for $915, according to the manufacturer. Testers also liked the charge LED display on the bottom of the unit, which gives a visual indication of unit output and can be used as a troubleshooting aid.

The Air Breeze’s downside is its limited field repair options, unless there have been significant changes from the AirX unit it replaces.

AMPAIR 100

One of two small-rotor units tested was the Ampair 100 manufactured by Boost Energy Systems of Berkshire, U.K. A six-bladed unit, the Ampair 100 has a maximum output of 100 watts and produces AC, which is then converted to 12- or 24-volt DC (selected at time of order) by two bridge rectifiers located in the unit's lower body. The DC output of the regulators is paralleled and passed to two carbon brushes (also mounted in the lower body) and then to two phosphor-bronze slip rings (mounted on the stationary pivot shaft) allowing the unit to follow the wind 360 degrees without the use of commutator brushes. According to the manual, maximum output current automatically remains at a safe level due to self-inductance of the heavy-duty windings—it goes on to say that similar sized machines (with low inductance and light-duty windings) have to be protected against burnout by the use of temperature-activated cut-out switches.

The Ampair 100 is built like a tank. The unit consists of a painted, two-part cast aluminum body with attached aluminum tail vane. Fit and finish were excellent, and all other inspected external components were either stainless steel or of composite construction. Internally, there are two six-pole permanent magnet rotors (with poles in line) mounted on a stainless-steel shaft, which runs in two sealed, grease-packed ball bearings. Two six-pole stators (one located in the main body casting, the other in the nose cone) are arranged with their poles staggered at 30 degrees to minimize "cogging," which can prevent a rotor from starting in light winds.

Although the Ampair 100 produces AC, its bridge rectifiers are located within the unit base (eliminating the need for a separate box), so installation is essentially the same as a unit that produces direct DC. If a blade is damaged, it and its opposing mate will have to be replaced together. However, you can run the unit (at reduced performance) with two blades removed until you get your replacements.

Start-up speed for the Ampair 100 is approximately 7 knots, and while the maker designates no maximum wind speed (only that it's designed to survive storms), its manual does state that it's a good plan to secure the unit if a severe storm is expected. There is a stop switch option. Without this switch, securing the unit involves these steps: grab the tail fin, swing the unit out of the wind, wait for it to stall, then secure the blades with a rope or bungee cord. The Ampair has a hole in the tail fin so users can grab it with a boat hook or an attached line.

The Ampair 100 is designed so it can be stripped in the field to replace damaged or worn components. The supporting literature is the best of the group—a well-illustrated manual, exploded views with part numbers, a troubleshooting guide, as well as a suggested list of spare parts for cruising in remote locations.

The Amp Air finished last after each 24-hour test period.

Bottom Line: Compared with the entire test group (large- and small-rotor units), the Ampair was very well-constructed and exceptionally quiet. Compared to its nearest competitor, the Rutland, the Ampair's heavier construction and the ability to repair problems in the field give it a slight edge for those cruising in more remote locations. Its downsides are its output (the lowest of all the units tested) and its weight (the heaviest of all units tested).

KISS High Output

Manufactured in Trinidad by KISS Energy Systems and distributed in the U.S. by Hotwire Enterprises, the KISS High Output wind generator is a large-rotor, three-blade unit designed with Caribbean cruisers in mind. The name being an acronym for keeping things simple, the KISS generator uses a low-key, yet effective design to produce a unit that is not only rugged, but also easily serviced "in the wild" with parts readily available throughout the world. Its three-year warranty allows for authorized repair by another facility while you're out cruising.

Available in 12-, 24-, and 32-volt models, the KISS generates AC that is converted to DC by a 30-amp automotive diode pack and then fed directly to the ship's electrical system. It uses a brushless, three-phase alternator. As mentioned in our first wind generator article, one advantage to this approach is that there's less voltage drop in AC wiring than in DC, a plus for installations with longer wire runs (such as a mizzen mast installation).

The KISS can be shut down via the provided on-off switch and is also protected from overheating by two thermal-sensitive bimetallic circuit breakers connected to the coils of the stator.

While not as finely finished as the other units tested, the KISS is nonetheless well constructed and pretty much bulletproof. It uses a sealed fiberglass motor housing and weighs only 17 pounds (plus 13 feet of wire at about 6 pounds), making it the second lightest unit we tested. The motor fits directly into its two-piece fiberglass housing, which is bolted together (through the motor) with four stainless-steel bolts and sealed with silicone. (An oil seal on the motor shaft provides additional weatherproofing.)

Other features include an alternator designed specifically to match the low speed characteristics of the rotor blades, epoxy-coated neodymium iron-boron magnets and plastic sealed No. 6203 metric ball bearings (commonly available worldwide) which, as per the manual "ensures that maintenance will be infrequent, simple, and inexpensive."

The KISS essentially comes in two parts: the generator body and rotor (which the blades are bolted to). The blades are highly cambered with twist, taper, and elliptical tips for maximum torque at relatively low RPMs and reduced blade noise. Each blade is made of five layers of bi-axial glass roving, pressure molded in polyester for strength with minimal flex and very light weight. All three blades are bolted to the rotor, which screws onto the threaded motor shaft.

The three blades are selected at the factory to have similar dynamic weights, however final balancing by the customer is required once installed on the rotor. This is a straightforward process accomplished by trimming a strip of lead tape attached to each blade. The reason given for having the customer balance the blades was so they would be better balanced upon assembly (after shipping). If you don't want the hassle, Hotwire Enterprises will pre-balance the blades for an additional $25.

As the blades are sold as sets (based on similar weights), the company recommends replacement of all three ($210) should a single blade be damaged. However, you can keep undamaged blades as emergency spares, balancing them with the spare lead tape provided.

The KISS is the only unit tested that did not use some form of rotary contact (a feature that allows multiple, 360-degree rotations). Instead, the unit comes with a tether connecting the tailfin to the mounting post, allowing the unit to turn no more than three revolutions in either direction. The manufacturer states that it's rare that the unit will turn 360 degrees. A light spring installed in the mount tends to turn the unit back to the forward position when the wind stops. Optional mercury-contact slip-rings providing infinite 360-degree operation are available from Hotwire for an additional $200.

Start-up speed for the unit we tested was advertised at 7 to 8 knots, and while the KISS is guaranteed to hurricane winds, thermostats in the motor will begin cutting output at around 20 to 25 knots to prevent overheating. The KISS produced noticeably less power than the other three-blade units on the windy Days 2 and 4. The manual states that you'll probably want to shut the unit down above 25 knots. This can be accomplished by utilizing the electric stop switch mounted in the control box.

The stop switch will slow the blades to a near stop in winds up to 42 knots (allowing you to secure the blades with a line). You can also manually shut down the unit using the line from its the tail to swing the tail into the wind. The KISS does not use set screws to attach the hub to the shaft, so it's very easy to remove the blade assembly and stow below for hurricane preparation. The housing itself presents little windage. The KISS banked the most amp hours on Day 1, and was the only generator that did not record its highest output on Day 4.

Bottom Line: The strong points of the KISS include simple, robust construction, excellent output for the tradewind cruising for which it was designed, and last—but certainly not least—the ability for the owner to repair virtually all aspects of the unit in the field. Downsides include slightly higher noise levels, the requirement for the customer to balance the blades (not due to difficulty, but as an additional step and potential problem if done incorrectly), and lower overall output than the other large diameter units tested.

Rutland 913

The Rutland 913 is the second six-bladed, small-rotor, wind generator featured in our test. Output of the Rutland 913 is 12 volts DC, and it is manufacturer-rated to deliver up to 250 watts. It is designed to provide power (via a battery or bank of batteries) to 12-volt or 24-volt systems. At $995, it is the least expensive production model we tested.

The Rutland 913 features all marine-grade materials and stainless-steel fittings. Highlights include a high-inertia generator, stator windings developed without an iron core (for low friction and low start-up speed), fiberglass encapsulated stator coils for reduced stator failures, and dual-encapsulated single magnets (eliminating the need for multiple, glued into place magnets).

The Rutland also features automatic thermostat protection (for use during prolonged high winds) and a start-up speed of 5 knots—the lowest of all the units tested. A shut-off switch is available with the optional HRDX charge controller ($295). The standard HRS charge controller is $149.

The Rutland 913 was not as heavily built as the Ampair, but construction was of a high quality. The Rutland comes pre-assembled with the exception of the blades and nose cone, both of which were very easy to install. The six turbine blades are a glass-reinforced nylon composite.

If a blade is broken, it should be replaced along with the opposing blade to maintain balance. However, until replacements are installed, the 913 can still be operated by removing every other blade, so that it is still in balance.

The Rutland manual doesn't list a maximum operating wind speed. It does mention that higher winds may trigger the unit's built-in thermostat to prevent the generator from overheating. If it does, output stops, and the turbine will temporarily speed up until the unit's internal temperature drops back down to normal, after which it starts charging again. The manual indicates you may see this cycling in prolonged winds (particularly in higher ambient temperatures), and that if storm winds are forecast, you may want to secure the unit to minimize wear and tear.

The 913 "is designed for continuous running to achieve maximum resistance to water ingress," and if restrained for any extended length of time, it should be covered.

The Rutland 913 does not have a stop-switch option. Stopping is essentially the same procedure as with any wind generator without a braking option: Grab the tail, swing the unit out of the wind (180 degrees), and once the unit stalls, throw a rope around a blade or two and tie to the mounting pole.

There's a small hole in the lower lobe of the Rutland's tail assembly to make this operation a bit safer by allowing you to grab the tail with a boat hook. You can also install a small tagline through the same hole to make it safer to grab whenever you need to secure the unit—just be sure it won't tangle in the blades.

Bottom Line: The Rutland 913 was the quietest unit in our test group, having a slight edge over the Ampair 100, its closest competitor noise-wise. (Not surprisingly, the two small-rotor units were the quietest of the group). The Rutland was well-constructed, had the lowest start-up speed and the quietest operation. Compared to the other small-rotor unit, the Ampair 100, it produced more and was quieter (although only slightly so). The decision between these two boils down to the Ampair's rugged construction and repairability versus the Rutland's slightly better performance.

The Rutland 913 finished next to last on every day except when the wind was light on Day 3, when it was 0.5 amp hours behind the Superwind.

Superwind 350

The Superwind 350 is a three-bladed, large-rotor unit manufactured by Superwind GmbH located in Bruhl, Germany, who recently signed on U.S. distributor Starboard Sun Corp. of Amherst, N.Y. (*www.starboardsun.com*).

The Superwind is a 350-watt unit that produces DC current and is available in 12- or 24-volt output. Similar to what you'd see in larger wind turbines, the Superwind's rotor control system adjusts the pitch angle of the blades for power and for limiting rotor speed, even during extreme wind velocities. In winds over 24 knots, the rotor control system adjusts blade pitch to keep power output constant.

The Superwind's fit and finish were excellent. The generator body, rotor, and tail assembly are powder-coated "sea water-proof aluminum." Total weight for the assembled unit is approximately 25 pounds. Features include a no-maintenance, permanent magnet design incorporating neodymium magnets in a three-phase generator with an internal rectifier. The Superwind comes with a three-year warranty on parts and workmanship, however, it does have some basic exclusions, such as floods, lightning strikes, fire, etc.

The Superwind is delivered in three easily assembled parts: the generator body, rotor (which the blades are attached to), and the tail, or wind vane. Each carbon fiber-reinforced blade is mounted to the rotor using two flush-mounted, stainless-steel Allen head screws. The blades come balanced from the factory, meaning if one blade is damaged, you'll have to replace all three at a cost of about $250, plus shipping.
It was the most difficult to install, requiring that you measure, drill, and tap two metric holes in the schedule 40, 1 1/2-inch tube to accept the mounting bolts. An optional adaptor for mounting on 2-inch diameter steel or aluminum pipe is also available.

The Superwind produces DC, so the electrical installation is pretty straightforward and well-documented in the manual. Due to high power output, installation of a battery charge controller and a stop switch is highly recommended. Superwind sells its own controller for $480 and a stop switch for $89.

The Superwind manual has a basic troubleshooting flow chart, but if it's anything more complicated than replacing damaged blades, swapping out the carbon brushes or checking for blown fuses, you'll likely have to send the unit for repair.

The Superwind edged out the Air Breeze with overall output, and was the top performer in every period, except the first, when it recorded the second lowest output total.

Bottom Line: The Superwind was the overall winner with regards to putting amp hours in the proverbial battery bank. It was very well constructed, relatively quiet for a large-rotor unit, and performed well, even on the lowest wind day (relative to the other models). Its downsides include limited field repair options, a hefty price tag, and the fact that it is a newcomer to the U.S. market.

Conclusion

Clearly, we are looking at two different animals here: quiet, lower-output, five-bladed units that deliver power on most days when there's a breeze; and three-bladed units that can bank some serious amp hours when the wind is up. Although the test period was relatively short, it brought a good mix of light- and strong-wind days, so testers were able to monitor output in a variety of conditions. Although isolating each period is instructive, the final average for the four days is, in our view, the most useful number.

Wind speed for the 4-day period averaged 12.6 knots, with two blustery days, so we're not surprised the high-output, three-bladed wind generators topped the five-bladed ones overall.

The Superwind did the best on every day, except Day 1, when winds mostly hovered around 10-12 knots. Most striking was the Superwind's superior performance on the mostly light-wind Day 3. More importantly, Superwind was a robustly built unit that ran quietly while it went to work. It is also the second heaviest unit and the most expensive by far.

If there is any concern we about the Superwind (besides the price), it's that it's new to the U.S. and only recently signed on with a distributor here. Wind generator makers have come and gone over the years, and we hope this one—started in 2004—sticks around.

The Air Breeze prototype looks very promising and might even have been the Best Choice, except that we have not tested the actual unit that will be for sale. If you’re not in a hurry to buy, you should wait for our update on that model. The KISS, which climbed to the top on Day 1 and placed third in output overall, is our Budget Buy for high-output models, and would be well-suited for tradewind cruising. It suffered in winds less than 10 knots and was slightly noisier, but it is well built, and for DIY types, it is eminently serviceable.

Of the silent running, six-bladed wind generators, the Ampair gets a recommendation for serious cruisers who want "built-like-a-tank" construction, and repairability in the field. The Rutland 913 is our Budget Buy in the five-bladed category. Based on our testing, it is the most affordable route to quiet windpower and superior output in light wind conditions.

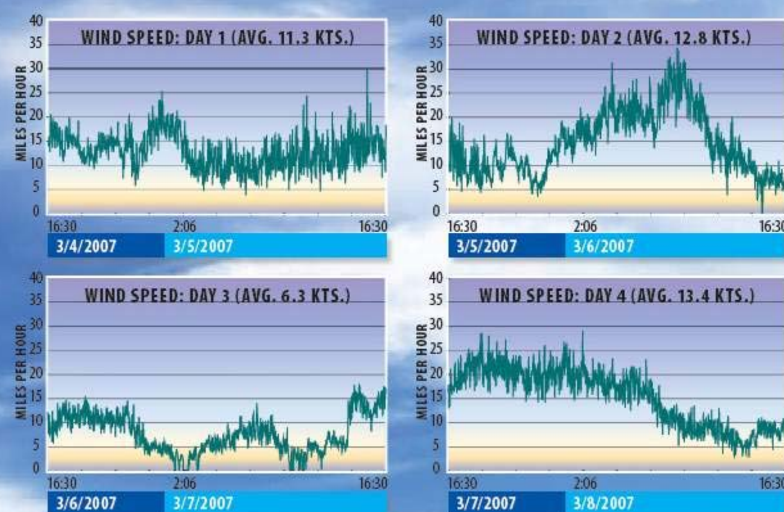
WIND GENERATOR OUTPUT — FOUR-DAY TEST RESULTS

UNIT	DAY 1	DAY 2	2-DAY AVERAGE	DAY 3	3-DAY AVERAGE	DAY 4	4-DAY AVERAGE	4-DAY TOTAL	24-HOUR MAXIMUM
RUTLAND 913	26.9 Ah	49.2 Ah	38.05 Ah	7.7 Ah	27.9 Ah	57.7 Ah	35.38 Ah	141.5 Ah	57.7 Ah
AMP AIR 100	18.7 Ah	39 Ah	28.85 Ah	2.6 Ah	20.1 Ah	44.9 Ah	26.3 Ah	105.2 Ah	44.9 Ah
KISS HIGH OUTPUT	55.5 Ah	88.1 Ah	71.8 Ah	2.7 Ah	48.7 Ah	84.4 Ah	57.68 Ah	230.7 Ah	88.1 Ah
AIR BREEZE	41.7 Ah	95.7 Ah	68.7 Ah	5.1 Ah	47.5 Ah	109 Ah	62.88 Ah	251.5 Ah	109 Ah
SUPERWIND 350	25.1 Ah	108.8 Ah	66.95 Ah	8.2 Ah	47.3 Ah	115.8 Ah	64.48 Ah	257.9 Ah	115 Ah

TRACKING OUTPUT

The APRS World Data Logger recorded wind velocity at 30-second intervals, and generated the adjacent wind speed data graphs for each 24-hour period (16:30-16:30). The table (below) shows output in amp hours (Ah) at the end of each 24-hour period and the cumulative averages after each day of testing. By comparing the data you can get an idea how each generator fared in light (Day 3), moderate (Day 1), and strong-wind days (Days 2 and 4), and all four days combined.

AVERAGE WIND SPEED FOR 96 HOURS=10.9 KTS.



WIND GENERATOR BLADE DESIGN

Since blade tips and trailing edges affect cut-in speed, torque, and wind noise, new blade research often focuses on these areas. Both the Superwind 350 and the Ampair 100 were noticeably quieter than the KISS. Small diameter turbines, like the Ampair, are generally quieter to begin with.

Superwind 350


Ampair 100


KISS High Output

PS VALUE GUIDE WIND GENERATORS

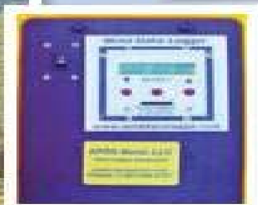
UNIT	AIR BREEZE*	$ KISS HIGH OUTPUT	★ SUPERWIND 350	✔ AMPAIR 100	$ RUTLAND 913
PRICE	$915	$1,200	$1,600	$1,200	$995
WEIGHT	13 lbs.	17 lbs.	25 lbs.	28 lbs.	23 lbs.
ROTOR DIAMETER	46 in.	29 in.	47.3 in.	36 in.	35.8 in.
CLAIMED OUTPUT	200 watts @ 24 knots	25 amps (300 watts) @ 25 knots	350 watts @ 24 knots	100 watts @ 30 knots	250 watts @ 38 knots
CLAIMED CUT-IN SPEED	7 knots	7.5 knots	7 knots	7 knots	5 knots
INITIAL OUTPUT	DC voltage	AC voltage	DC voltage	AC voltage	DC voltage
THERMAL REGULATION	No	Yes	No	No	Yes
OVERSPEED PROTECTION	Electronic torque control	Stop switch	Variable pitch blades, optional stop switch	Manual, optional stop switch	Manual, optional stop switch
WARRANTY	3 years	3 years	3 years	1 year	1 year
BLADE PRICE	$95/set	$210/set	$250/ set	$50/pair	$35/pair
NOISE (RANKING)	3	5	4	2	1
EASE OF INSTALL	Excellent	Good	Fair	Good	Good
CONSTRUCTION	Good	Good	Excellent	Excellent	Good
OWNER REPAIRABILITY	Fair	Excellent	Fair	Good	Fair
OWNERS MANUAL	Not yet ready	Good	Good	Excellent	Good

★ Best Choice ✔ Recommended $ Budget Buy

**Practical Sailor* tested only a prototype, so this unit was not rated.

HOW WE TESTED

1



2

1. Each wind generator fed to a control box fitted with (left to right) a SeaVolt 12-volt battery, a Xantrex XBM battery monitor (inset right), a Xantrex C40 charge controller, and a dump load. **2.** The portable APRS World Data Logger, with anemometer and water-tight control box, logged wind speed at the test site.

The test was conducted in early March 2007 at an unobstructed, waterfront site situated on the southern Chesapeake Bay. The units (mounted on 6-foot poles) were arranged at 20-foot intervals and staggered at roughly 18-foot intervals in an effort to reduce the effects of wind turbulence generated between the units.

Each wind generator test/monitoring setup was the same and included the following: a 12-volt West Marine SeaVolt Starting 550 battery, a Xantrex XBM Battery Monitor (www.xantrex.com), a Xantrex C40 Charge Controller, and a resistive or "diversion" load, leased from Hotwire Enterprises (www.hotwire.com). Output power (in amp hours) was measured and logged by the XBM. The meter was installed such that true output was recorded independent of battery state of charge.

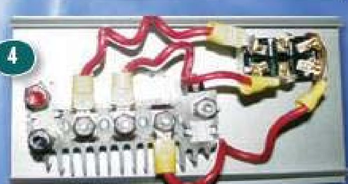
The test was carried out over four consecutive days—a 24-hour burn-in period was used to verify proper operation of all wind generator units and test setups prior to the test's start.

Wind speeds at the test site were recorded throughout the test period using a self-contained Wind Data Logger unit provided by APRS World of Winona, Minn. (*www.aprs2world.com*). Spot readings were taken utilizing two handheld wind indicator units, a VORTEX handheld wind anemometer provided by Inspeed.com (*www.inspeed.com*) and a Kestrel 4000 provided by Nielsen Kellerman (*www.nkhome.com*).

Noise was measured using a Radio Shack digital decibel meter set on the slow response scale. This posed the most problematic part of the test, particularly with higher wind speeds, due to interference of the ambient wind noise. Expensive government tests have run into the same problems. Testers, however, could easily detect the whine of the generators over the wind noise, and our rankings are based on testers' subjective findings at the test site and later, upon video review of the units at 10 knots and 25 knots of wind. The difference between the quietest units (the Rutland and Ampair) and the least quiet unit, the KISS, was clearly noticeable, while the middle-range units were very close in terms of noise.

Testers took spot wind readings and checked noise from each side of the unit at various wind speeds.

TURBINE DETAILS



1. The Air Breeze's mounting clamp.
2. Balanced pairs of blades on the Amp Air 100 are marked with matching colored "X"s.
3. The Superwind 350's blades are recessed to fit into their pivoting shaft.
4. The KISS control box holds the stop switch (upper right) and AC-DC rectifier.
5. The lightweight Rutland was quick to assemble.

THE CONTENDERS

Air Breeze Prototype

Ampair 100

KISS High Output

Superwind 350

Rutland 913